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Neeraj Kumar
Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Sandeep Kumar
Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Uppu Sai Sravan
Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

SP Singh
Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence
Uppu Sai Sravan
Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Growth and yield performance of aromatic rice (*Oryza sativa* L.) as influenced by bio-organics and fertility levels

Neeraj Kumar, Sandeep Kumar, Uppu Sai Sravan and SP Singh

Abstract
The present investigation was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi, U.P., India to evaluate the effect of fertility levels and bio-organics on growth and productivity of recently released short grain aromatic rice cv. HUR 917. The experiment was laid out in factorial randomized complete block design with four fertility levels *i.e.* control, 50% RDF, 75% RDF and 100% RDF and three bio-organics *i.e.* control, FYM and FYM + BGA, replicated thrice. The results revealed that 100% RDF has significantly improved growth parameters, yield attributes, yield, NPK removal and net returns over other fertility levels tested. Combined application of FYM + BGA produced significantly higher growth parameters, yield attributes, yield, NPK removal and net returns over FYM and control. Hence, aromatic rice can be grown with 100% RDF and FYM along with BGA for higher growth, productivity and net returns under eastern U. P condition.

Keywords: Bio-organics, Fertility levels, Aromatic rice, BGA, FYM

Introduction

Aromatic rice constitutes a prime position in India because of their aroma, grain dimension, cooking qualities and is preferred for consumption globally and fetches premium price in domestic and international markets (Khan *et al*., 2003 [12]; Singh *et al*., 2012) [32]. The demand for aromatic rice has dramatically increased over the past two decades due to change in the consumer's preference for better quality rice. The farmers have switched over to high yielding modern varieties because of the higher yield which compensates for the premium price of scented rice. India has to produce 170 to 180 million tonnes of rice (115-120 million tonnes of milled rice) by 2020 with an average productivity of 4.03 t ha^{-1} to maintain present level of self-sufficiency (Mishra *et al*., 2006) [20]. It is therefore important to achieve high yield from scented rice varieties, with maintaining its quality too. Traditional aromatic rice varieties were tall, susceptible to pest and disease incidence and are low yielders. Hence, a new short grained aromatic high yielding rice variety HUR-917 (Malviya Sugandh Dhan-917) was developed at Banaras Hindu University, Varanasi Center through selection method of conventional breeding approach from Dehradun Basmati Selection- 13 (DBS-13) in 2014. This variety yielded 4.2 - 4.5 t ha^{-1} in Indo Gangetic Plain Zone of India and was suitable for varanasi region due to its specific quality and texture. Its yield is still low compared to its potential which needs to be uplifted while maintaining or improving its quality with efficient utilization of input factors. This objective cannot be achieved by chemical or organic nutrient sources alone. Chemical fertilizers are well known for their effects on the yield increment whereas organic nutrients enhance the quality and aroma (Prakash *et al*., 2002) [29].

Presently adverse effects like decline in yield, soil fertility, and factor productivity are raising concerns about sustainability of the production system. Indiscriminate use of chemical fertilizers resulted in deterioration of soil physical, chemical and biological health in rice growing areas. The increasing land use intensity without balanced use of chemical fertilizers with little or no use of organic manure have caused severe fertility deterioration of soils resulting in stagnating or even declining crop productivity (Shormy *et al*., 2013) [30]. There is growing concern about sustainability of the rice production system due to stagnation of yield and decline in rice yield is now realized in many states like Punjab, Haryana, eastern Uttar Pradesh, Madhya Pradesh, Bihar, Himachal Pradesh and Jammu and Kashmir (Chand and Haque, 1998 [6]; Ladha *et al*., 2000 [15]; Mahajan *et al.* 2002 [17] & 2008 [16] and Paroda, 1996) [28]. Increasing the productivity is a hard task due to emerging multi-nutrient deficiencies, imbalance use of fertilizers, and declining soil organic matter. The cost of fertilizer is increasing and their excessive use also results in pollution of environment and deterioration of groundwater quality. These problems can be addressed efficiently by integrated nutrient management practices. Bodruzzaman *et al*. (2002) [3] opined that the combined use of organic manures with inorganic fertilizers performed better than sole inorganic fertilizer to sustain the soil fertility and rice productivity. Therefore, a suitable combination of organic and inorganic source of nutrients is necessary for sustainable rice production that can ensure food production with high quality. Thus, a field experiment was conducted to improve production and profitability of recently released basmati variety HUR- 917 with the use of organic manures and inorganic fertilizers.

Material and Methods

The present experiment was carried out at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* season of 2016. Geographically, experimental site falls under sub-tropical zone of Indo-Gangetic plains, located at 25^0 27'N latitude, 82^0 99'E longitudes and at an altitude of 75.7 meters above mean sea level. The soil at the experimental site was sandy clay loam in texture with pH of 7.56, EC of 0.32 dS m^{-1}, low in organic carbon (3.9 g kg^{-1}), available nitrogen (255.07 kg ha^{-1}), phosphorus (21.60 kg ha^{-1}) and medium in available potassium (196.80 kg ha^{-1}). Factorial experiment was laid out in Randomized Complete Block Design (RCBD), replicated thrice assigning combination of four NPK levels (control, 50% RDF, 75% RDF and 100% RDF) and three bio-organics (control, FYM, and FYM + BGA). Fertilizers were applied @ 80-40-20 kg N: P_2O_5: K_2O ha^{-1} through Urea, DAP and MOP, respectively. FYM was applied @ 10 tonnes ha^{-1} which contains 0.52 per cent nitrogen, 0.20 per cent phosphorus and 0.48 per cent potassium on dry weight basis. The dried and powdered composite algal culture (*Calothrix, Anabaena* & *Aulosira*) obtained from IARI, New Delhi was applied at the rate of 10 kg ha^{-1} as per treatment in standing water at 10 days after transplanting. Seed rate used for raising nursery was 30 kg ha^{-1} and four week old seedlings were transplanted on the puddled field at the rate of two seedlings $hill^{-1}$ at row spacing of 20 × 15 cm. Half of the recommended dose of nitrogen, full dose of phosphorus and potassium were applied basally as per treatment before transplanting. The remaining half nitrogen was applied in two equal splits at active tillering and panicle initiation stages. However, farmyard manure (FYM) was applied 2 days before transplanting. Irrigation was given to the crop as and when needed according to the crop requirement and rainfall pattern. Throughout the crop period, three irrigations were given and about ± 5 cm water level were continuously maintained till flowering and after that field were kept under saturated condition. The crop was harvested at proper maturity. All the biometric observations recorded as per standard procedures. Nitrogen content (%) was estimated both in grain and straw by modified Kjeldahl method as described by Jackson (1973) [10]. Phosphorus content (%) in grain and straw was determined by Vanadomolybdo phosphoric acid yellow colour method as suggested by Jackson (1973) [10]. Potassium content (%) was estimated with the help of Flame photometer as described by Jackson (1973) [10]. Nutrient removal was worked out by multiplying respective contents with their yields. Protein content (%) in grain was worked out by multiplying the nitrogen content in grain by the factor 6.25 (A.O.A.C, 1970) [1]. The cost of cultivation was worked out by taking into consideration all the expenses incurred. The cost of input and price of produce prevalent at the Agricultural Research Farm, Banaras Hindu University were taken into consideration for calculating economics of different treatments. Gross return was worked out by multiplying grain and straw yield with their prevailing market prices and expressed in rupees per hectare. The net return (₹ ha^{-1}) was calculated by deducting cost of cultivation from gross return. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984) [9]. The difference in the treatments mean were tested by using Least Significance Difference (LSD) at 5% level of probability where 'F' test showed significant difference among means.

Results and Discussion

Growth Parameters

The data on mean values of growth parameters pertaining to different treatments are presented in Table 1. In the present investigation, marked effect of the NPK levels were noticed on growth parameters *viz*. plant height, number of tillers $hill^{-1}$, dry matter production and leaf area index. Increasing fertility levels from 0% to100% RDF progressively improved all the growth parameters *viz.* plant height, number of tillers $hill^{-1}$, dry matter production and leaf area index. This might be attributed to adequate availability of nutrients due to NPK levels, coupled with satisfactory moisture condition maintained throughout crop growing season which might have improved nutrient supplying capacity of soil. Better growth with increasing NPK levels indicates proper utilization of nutrients by the crop. These findings are in close agreement with those of Manzoor *et al.* (2006) [19], Naseer and Bali (2007) [26] and Murthy *et al.* (2015) [23].

The growth parameters were significantly altered by bio-organics (Table 1). Among the bio-organics, combined use of FYM + BGA recorded significantly higher growth parameters *viz.* plant height, number of tillers $hill^{-1}$, dry matter production and leaf area index as compared to FYM and control. Increase in growth attributes with application of FYM + BGA might be due to higher availability of nitrogen and phosphorus as confirmed by Dixit and Gupta (2000) [8]. Besides, BGA excretes Vitamin B_{12}, ascorbic acid and auxins, which may improve the growth attributes of rice crop (Kumar *et al*., 2007) [14]. It is evident from the above results that addition of BGA along with FYM had beneficial effect and improved the growth parameters which may be attributed to the synergistic effect and the response was augmented when used together. These findings are in direct conformity with that of Verma *et al.* (2008) [36] and Kumar *et al.* (2010) [13].

Table 1: Effect of fertility levels and bio-organics on growth parameters of rice

Treatments	Plant height at harvest (cm)	Number of tillers hill^{-1} at harvest	Dry matter production (g hill^{-1}) at harvest	Leaf area index at 90 DAT
Fertility levels (%RDF)				
0	101.16	5.50	22.69	3.16
50	108.48	6.17	26.77	3.47
75	110.52	6.49	28.54	3.86
100	113.66	6.82	31.15	4.27
S.Em.±	0.72	0.07	0.36	0.08
CD (*P*=0.05)	2.13	0.22	1.08	0.23
Bio-organics				
control	105.47	5.99	24.76	3.37
FYM	108.20	6.19	27.60	3.55
FYM + BGA	111.69	6.55	29.51	4.15
S.Em.±	0.63	0.06	0.31	0.07
CD(*P*=0.05)	1.85	0.19	0.93	0.20

Yield attributes and yield

Yield attributing characters *viz.* panicles m^{-2}, number of filled grains and unfilled grains panicle^{-1} and 1000- grain weight (Table 2) were studied. Distinct positive effect of fertility levels were noticed on these yield attributes. All these parameters attained higher values with increasing NPK levels up to the highest level (100% RDF). This might be due to higher assimilation of nutrient which leads to higher dry matter accumulation and transportation towards sink. Effective translocation of assimilates to the sink might have resulted in sound filling of grains as revealed by the highest number of filled grains panicle^{-1} (Bouman *et al*., 2006) [4]. The results of the present experiment confirmed the findings of Murthy *et al.* (2015) [23]. Increasing fertility levels invariably enhanced the grain yield (Table 2). The highest level 100% RDF produced maximum grain yield due to higher number of panicles m^{-2}, filled grains panicle^{-1} and 1000 grain weight. Increase in grain weight at higher NPK rates might be due to higher photosynthetic rate and translocation of photosynthates from source to sink (Kausar *et al*., 1993) [11]. Similar findings have been reported Mondal *et al*. (2013) [21], Singh *et al.* (2014) [34] and Srivastava *et al.* (2014) [35].

Yield attributes which determine yield, is the resultant of the vegetative development of the crop. All attributes of yield *viz.*, panicles m^{-2}, filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000-grain weight were significantly differed by different levels of bio-organics. The better yield attributes were recorded under combined application of FYM + BGA. This might be due to favourable effect of FYM which was helpful in release of nutrients in adequate amount and it also accelerated the algal and bacterial growth which provide atmospheric nitrogen and increased the availability of phosphorus in soil respectively, as compared to application of FYM or control. Increase in yield components, grain and straw yield might be due to higher photosynthetic activity because of increased leaf area index, which ultimately promoted dry matter production resulted in higher grain and straw yield. These results confirmed the findings of Davari and Sharma (2010) [7] and Singh *et al.* (2013) [33].

Table 2: Effect of fertility levels and bio-organics on yield and yield attributes of rice

Treatments	Panicles m^{-2}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000- grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Fertility levels (% RDF)							
0	181.31	166.66	26.66	12.92	31.27	57.15	35.33
50	206.91	183.88	22.33	13.70	36.34	63.49	36.39
75	214.28	193.33	18.55	13.82	40.28	68.65	36.96
100	225.07	200.00	15.44	14.28	42.45	71.24	37.33
S Em±	2.17	2.25	0.81	0.12	0.31	0.67	0.11
CD (*P*=0.05)	6.39	6.61	2.39	0.36	0.92	1.96	0.31
Bio-organics							
control	197.78	178.00	23.08	13.24	33.06	58.02	36.19
FYM	205.93	188.08	21.00	13.74	38.93	67.49	36.53
FYM + BGA	216.98	191.83	18.16	14.06	40.76	69.89	36.79
S Em±	1.88	1.72	0.70	0.10	0.27	0.58	0.09
CD(*P*=0.05)	5.53	5.05	2.07	0.31	0.80	1.70	0.27

Nutrient removal

Nitrogen, phosphorus, and potassium removal by grain and straw significantly increased up to 100% RDF (Table 3). Nitrogen, phosphorus and potassium removal by grain and straw significantly increased up to 100% RDF. A perusal of the data indicates that 100% RDF registered significantly higher uptake of nitrogen by grain (55.36 kg ha^{-1}) and straw (31.26 kg ha^{-1}) followed by 75%, 50% RDF and control, respectively. These findings are in close agreement with those of Murali and Setty (2001) [22] and Nanda *et al*. (2016a) [24]. The application of nitrogen in combination with P and K have resulted in increased availability of N, P and K in soil and also increased cation exchange capacity of roots which enhanced N, P and K absorption in plants. Thus, there was increased concentration of these nutrients in grain and straw and was in accordance with Pandey and Aggarwal (1991) [27]. The increase in the uptake of nutrients with the increasing doses of NPK may be due to better availability of these nutrients because of added supply and prolific root system developed by the balanced application of nutrients, resulting in better absorption of nutrients (Brar *et al.*, 1995) [5].

Among the bio-organic sources, the combined use of FYM +

BGA removed higher N, P and K by grain as well as straw followed by FYM alone (Table 3). This might be due to increased efficiency and cumulative synergistic effect of combined application of bio-organic sources resulted in increased uptake of nutrients. Primary nutrients removal by grain and straw were observed minimum with the control treatment. These findings are in close conformity with Maiti *et al.* (2006) [18].

Table 3: Effect of fertility levels and bio-organics on removal of nitrogen, phosphorus and potassium by rice crop

Treatments	Nitrogen removal (kg ha^{-1})		Phosphorus removal (kg ha^{-1})		Potassium removal (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Fertility levels (% RDF)						
0	35.98	19.46	9.46	3.06	8.39	66.81
50	43.08	23.17	11.63	3.79	10.29	74.34
75	50.70	27.28	13.54	4.59	12.04	84.78
100	56.36	31.26	14.89	5.48	13.41	94.69
S Em±	0.48	0.37	0.15	0.07	0.15	0.85
CD (*P*=0.05)	1.40	1.10	0.45	0.22	0.45	2.50
Bio-organics						
control	40.00	20.88	10.48	3.39	9.35	70.14
FYM	47.88	26.62	12.84	4.47	11.36	83.00
FYM+BGA	51.70	28.38	13.83	4.82	12.39	87.32
S Em±	0.41	0.32	0.13	0.06	0.13	0.74
CD (*P*=0.05)	1.21	0.95	0.39	0.19	0.39	2.16

Increased content and uptake of nitrogen is understood in view of positive effect of FYM, further augmented nitrogen content and uptake by rice crop. Similar findings have been reported by Bhat *et al.* (2005) [2].

Protein content and yield

Application of fertility levels significantly influenced the protein content (%) in grain up to 100% RDF (Table 4). The protein yield (kg ha^{-1}) was significantly influenced with increment of NPK levels from control to 100% RDF. The nitrogen is an essential constituent of protein and increasing N levels increased N content which led to increased protein yield. The combined application of FYM + BGA showed highest values which significantly influenced the protein content (%) and protein yield (kg ha^{-1}) in grain (Table 4). Integration of bio-organic sources might have increased the availability of nitrogen and other nutrients to the plant which ultimately influenced the protein yield favorably. Nitrogen is an essential constituent of protein and addition of bio-organic sources might have increased nitrogen removal leading thereby to enhanced protein content in grain. These results confirmed the finding of Dixit and Gupta (2000) [8].

Table 4: Effect of fertility levels and bio-organics on protein content (%) and protein yield (kg ha^{-1}) of rice

Treatments	Protein content (%)	Protein yield (kg ha^{-1})
Fertility levels (% RDF)		
0	7.17	224.76
50	7.39	269.10
75	7.85	316.74
100	8.28	352.03
SEm±	0.05	2.99
CD (*P*=0.05)	0.14	8.77
Bio-organics		
control	7.49	249.88
FYM	7.64	299.10
FYM+BGA	7.88	322.99
SEm±	0.04	2.59
CD (*P*=0.05)	0.12	7.60

Economics

Economics varied markedly by various treatments (Table 5). Among the fertility levels, the gross return and net return were higher under 100% RDF followed by 75% RDF, 50% RDF and control, respectively. The differences in gross and net returns were due to variation in yields. These findings were in accordance with Singh *et al.* (2017) [31]. The combined application of FYM + BGA recorded the highest cost of cultivation than the FYM and control. While, the maximum gross return and net return was observed under combined application of FYM + BGA because of higher yield under this treatment and are in agreement with the findings of Yogesh *et al.* (2013) [37], Singh *et al.* (2014) [34] and Nanda *et al.* (2016b) [25].

Table 5: Effect of fertility levels and bio-organics on the economics of rice

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})
Fertility levels (% RDF)			
0	30574.72	61968.04	31393.32
50	32460.82	71190.85	38730.03
75	33402.01	78436.16	45034.15
100	34346.92	82356.41	48009.49
SEm±	-	635.80	635.80
CD (*P*=0.05)	-	1864.72	1864.72
Bio-organics			
control	27229.45	64839.99	37610.54
FYM	35229.45	76129.98	40900.54
FYM + BGA	35629.45	79493.61	43864.16
SEm±	-	550.62	550.62
CD (*P*=0.05)	-	1614.90	1614.90

Conclusion

In summary, aromatic rice variety HUR-917 can be grown with NPK application @ 100% RDF (80-40-20 kg ha^{-1}) along with the combined application of FYM and BGA for achieving higher growth, yield and net returns.

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